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Origin of false components of NRM during conventional stepwise thermal demagnetization

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Abstract

Many Permian–Triassic dolerite samples from the Siberian Trap Large Igneous Province exposed to conventional stepwise thermal demagnetization at 250–450 ºC display mid-temperature remanence (MTC) directed opposite to the high-temperature NRM component. Alternating field (A.C.) demagnetization fails to isolate the antipodal component, but it appears during continuous thermal demagnetization, though in a different temperature range. Laboratory experiments and simulations prove that MTC remanence is an artifact resulting from magnetic memory of self-reversing titanomagnetite grains oxidized at low temperature. This effect can deform the results stepwise thermal cleaning and be responsible for misleading patterns of paleomagnetic directions. Given that oxidized titanomagnetite grains are widespread in volcanic rocks, we suggest to identify true paleodirections by combined continuous and stepwise thermal demagnetization. The extension of our model to the case of NRM_2 overprint directed at some angle to partially reversed primary NRM_1 component accounts for the difference between the results of stepwise and continuous thermal demagnetization observed in samples of the Steens Mountain basalt (USA).

Keywords: thermal demagnetization; magnetic memory; self-reversal; oxidized titanomagnetite; paleomagnetic directions

Introduction

Paleomagnetic directions are crucial to reconstructions of the morphology and history of the Earth's magnetic field and respective paleotectonic settings. Paleomagnetic studies stem from the assumption that natural remanent magnetization (NRM) in rocks aligns with the geomagnetic field at the time of rock formation. This postulate is valid in the first approximation but the situation is more complicated than that as the ultimate NRM vector is actually a sum of primary remanence and one or several secondary magnetization overprints. Thus, reconstructing the true direction of the past geomagnetic field requires removing the overprints, commonly by alternating field (A.C.) or stepwise thermal demagnetization, which destroys less stable NRM components and isolates the most stable one, assumed to be characteristic remanence (ChRM).

Conventional stepwise thermal demagnetization of a Miocene lava flow from Steens Mountain (USA) that presumably cooled during a geomagnetic polarity reversal revealed an unusual behavior of ChRM (Mankinen et al., 1985; Prévot et al., 1985). The ChRM direction in the 1.9 m thick lava flow B51 changes from bottom to top of the flow: it was parallel to the direction of the underlying flow B52 and then to that of the overlying flow B50. Actually, the paleodirections behaved in a more intricate way but we consider the main trend for simplicity. Possible causes of this change were largely discussed, for instance, in the overview by Coe et al. (2014), and the results of the conventional stepwise thermal demagnetization were found out to differ markedly from those of continuous cleaning. Below we provide details of the case reported by Coe et al. (2014) and discuss possible causes of the unusual ChRM behavior.

This study focuses on physical mechanisms that may lead to the discrepancy in results of stepwise and continuous thermal demagnetization. The observed effect is simulated in a phenomenological model based on rock-magnetic experiments. We suggest that the difference may be due to magnetic

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